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The principles of atomic structure which are stressed are that atoms are made up of a nucleus with a positive charge, surrounded by electrons with a negative charge, and that there is no change in the atom when the positive and negative charges are equal.

Experiments illustrate that current electricity is actually electrons in motion, that there is a difference between insulators and conductors, and that material may be conductive in one state and nonconductive in another state.

Students are encouraged to record all results and observations and to have proper scientific evidence for all statements.

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Nova Science Unit 15

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Fundamental Particles

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From your studies you know that stuff occupies a certain volume. We can also assume that atoms have volume. Practically all of the stuff of an atom is found in a small compact region called the nucleus. The rest of the volume of the atom is occupied by electrons. As you remember all matter is of an electrical nature. Our studies showed that some particles of stuff have negative electric charges and others have positive charges. Also when positive and negative charges are brought together the net result is no apparent charge. So it is with the atom. The nucleus has many particles in it that carry a positive charge. The electrons have a negative charge. When a number of electrons equal to the positive particles in the nucleus surround the nucleus then we have an atom with no apparent charge. Try this for yourself. Test such materials as sulfur, copper, and others and see if you can detect an electrical charge. So we see that atoms are made up of a nucleus with a positive charge surrounded by electrons with a negative charge. When there are an equal number of positive and negative charges we have a neutral atom.

Protons are in the nucleus and electrons surround the nucleus. This nicely takes care of the volume of an atom. What about the atomic mass? Well, scientists have been able to determine the mass of small particles. These are their results:

Particles	Charge	Mass (Relative to the Proton)
Electron	1 -	$\frac{1}{1800}$
Proton	1 +	1
Neutron	0	1

What do these mean? We find electrons around the nucleus and from the above we see what electrons weigh next to nothing so very little mass of the atom is to be found in the volume occupied by the electrons. What does that leave?

The nucleus with its heavy protons. We come to the conclusion that most of the mass of an atom is in the nucleus. The neutron? We'll meet this particle again but in the meantime do some research on this particle. Now what do we have? A heavy nucleus surrounded by extremely light electrons. A nucleus with a positive charge and electrons with a negative charge.

How large is an atom? We can't see atoms but scientists have devised methods of measurements (remember your first unit on measurements) that tell us much about the size of atoms. Suppose we take Yankee Stadium with its seating capacity of 67,000 people as a model for the atom. To keep the right scale the nucleus would be about the size of a flea. A little flea! For the hydrogen atom the flea would represent one proton. He would be located at the center of the stadium somewhere around second base. The one electron would wander around occupying <u>all</u> the rest of the stadium. For the helium atom the nucleus would be replaced by four fleas representing two protons and two neutrons. The two electrons of a neutral atom would now share the ample space of the stadium. To make the picture more complicated you must remember that the fleas in center field represent almost all the mass of the atom. Scientists have been able to use mathematical terms instead of fleas even though the fleas would probably be more interesting. The diameter of an atom varies from 0.000 000 01 cm to 0.000.000 05 cm ($1X10^{-8}$cm). Nuculei are much smaller. A typical nucleus diameter is 10^{-3}cm, or about 1/100,000 the atom diameter. Now do you wonder why we cannot yet see atoms???

Although you may not understand how electrons are forced to flow in wires, you do know quite a bit about what to do with them. You know how to turn on lights, how to avoid a shock when you plug in an appliance, and that wires around the house have insulation on them. In this unit you will need to learn

some circuitry in order to perform the experiments.

Experience over the years has shown us that people do not get shocked with low voltage dry cells. You will be working with "safe" electricity, so don't be afraid of it. You must be careful, though, or you will ruin our equipment and we will be unable to proceed.

You should know by now that current electricity is electrons flowing, generally in a conductor. Let us investigate and see what we can learn.

You should know by now that current electricity is electrons flowing, generally in a conductor. Let us investigate and see what we can learn.

If we begin with a test of good conductors, we may also learn about circuits. Let us use this piece of apparatus:

If a conductor will allow electricity to pass, when one is placed from A to B, the light will light. An insulator, on the other hand, would cause no change. Try different materials until you think you are able to predict whether something will be an insulator or a conductor. Many conductors are coated with insulators, so be careful!!!

Let us perform a series of test on various materials:

You should have discovered that metals are generally good conductors. Have you tried the metals in various states? Some problems are involved in this. Many metals are quite difficult to melt and even more difficult to vaporize. Lead, tin and zinc are easy to melt and these will give you an opportunity to judge their conductivity under varying conditions. Be wary of unqualified statements based

on little evidence. Record all your results and observations.

Do you suppose that a material might be conductive in one state and non-conductive in another? Your teacher will supply you with several materials. Try to see if they differ when they are a dry solid and when they are melted. Observe and record the names of these materials and the results of your tests.

Can you think of other changes that can be made in materials that might affect their conductivity? One very important one is solution. Test some distilled water, then test tap water. Add some of the material from the last experiment to the water. Record whether they dissolve or not, and what changes, if any, took place in the conductivity of the solution.

Keep in mind that current electricity is electrons in motion. How do you suppose the way that they move might be different in solids, in liquids, and in solutions?

In the case of metals there are electrons that are not tightly bound to the nucleus. These are moved slowly through the metal by forcing electrons in one end of the metal.

What happens in a solution? Somehow the electrons must move from one contact to the other. How can we explain this, and what evidence can we find for it.

You have learned a little about atomic structure and you will learn about chemical reactions in the next two units. For simplicity now, let us say that an atom or molecule should contain the same number of electrons that it has protons. If it doesn't it will be a charged body and we call these ions. An atom, molecule, or part of a molecule that has an extra electron or more is a negative ion. One that has lost an electron or more is a positive ion. Maybe we could make these particles work for us by carrying charges through the solution or even cause them to push electrons along as they do in a chemical dry cell.

Metals are composed of atoms that are quite willing to give up electrons. What is the charge on a metallic ion? Let us repeat some of the discovery patterns that we have used before.

Proposal:

(1) Some compounds containing metals dissolve in water to form ions. The metals form positive ions.

(2) Some metals are more anxious than others to give away electron.

(3) The properties of the ion may be different than the properties of the atom.

Let us proceed to place different metals aquerous metallic solutions. As usual, we will keep a record of conditions before the metal was placed in the solution, any observations we might have during a given time interval, and the final results of our experiment. Using a combination of metals and solutions, (1) set up a scale of the activity of the metals (2) present some evidence that ions of a metal are different than atoms of a metal, (3) explain how the presence of ions might account for observations.

By this time, you should be forming a picture of what ions are like. You might even be thinking of ways that they would behave. What would happen to one if it were placed between two plates that were charged - one positive and one negative? Would there be much of a change in behavior if the ion were in a solution instead of a vacuum. Be sure you have reasons for your answers.